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***What Happens After the Central Bank of
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1%?***

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What Happens After the Central Bank of Brazil Increases the Target Interbank Rate by 1%?*

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Abstract

I start presenting an explicit solution to Taylor's (2001) model, in order to illustrate the link between the target interest rate and the overnight interest rate prevailing in the economy. Next, I use Vector Auto Regressions to shed some light on the evolution of key macroeconomic variables after the Central Bank of Brazil increases the target interest rate by 1%. Point estimates show a four-year accumulated output loss ranging from 0.04% (whole sample, 1980 : 1-2004 : 2, quarterly data) to 0.25% (Post-Real data only) with a first-year peak output response between -0.04% and -1.0% , respectively. Prices decline between 2% and 4% in a 4-year horizon. The accumulated output response is found to be between 3.5 and 6 times higher after the Real Plan than when the whole sample is considered. The 95% confidence bands obtained using bias-corrected bootstrap always include the null output response when the whole sample is used, but not when the data is restricted to the Post-Real period. Innovations to interest rates explain between 4.9% (whole sample) and 9.2% (post-Real sample) of the forecast error of GDP.

*I am thankful to participants of workshops at the University of Chicago, for their comments, and to Lutz Kilian, for making available some of the computer codes used in this work. The usual disclaimer applies. Key Words: Inflation, Brazil, COPOM, Open-Mouth Operations, VAR, Vector Auto Regression, Bias-Corrected Bootstrap. CEL codes: C15, E40, E50.

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1 Introduction

The current approach to monetary policy in Brazil is characterized by the setting of two different targets: the inflation target and the targeting of the rate at which financial institutions lend each other reserves overnight (the interbank overnight interest rate target). Inflation targeting was introduced in Brazil in July/1999. Once the policy of controlling the nominal exchange rate was abandoned by the Central Bank, at the beginning of 1999, a new forward-looking regime enhancing transparency and the control of expectations emerged as the right thing to do.

The interbank-rate targeting is the main operational direct tool by means of which inflation is kept equal or close to its target¹. It amounts in practice to two coordinated policies conducted by the Central Bank. The first policy regards the announcements of the interest-rate trends and/or targets for the near future. It is a responsibility of the COPOM ("Comitê de Política Monetária"), which holds monthly meetings with this purpose. The second policy, a responsibility of the Central Bank's Trading Desk (Mesa de Operações da DIOPE- Divisão de Operações), amounts to making daily open-market operations, in such a way that supply and demand for reserves intersect at an interest rate equal or close to the desired target². There is no direct interference of the Central Bank, through its Trading Desk, on the interbank rates.

Since the target interest rate is a crucial tool for the day-by-day policies of the Central Bank, it is very important to know how changes in this rate affect other relevant macroeconomic variables such as the GDP, employment and inflation.

Several elaborate econometric works have been produced by the Central Bank of Brazil since the introduction of the Inflation-Targeting regime, in order to provide a technical background for the forecasts to be announced. Among them, Bogdanski et al. (2000) concentrates on the dynamics involving interest rates, prices and output. These authors have concluded, using structural models, that interest rate changes affect aggregate demand in a period of 3 to 6 months, output gap having an impact on inflation after 3 months. This makes a total around nine months between a policy action based on the interest rate and curbing inflation. Tabak (2003) has found

¹Of course, the setting of this rate is also made with an eye towards the relative rates of change of some monetary aggregates.

²Martins (2003) and Barbosa (2005) are two available references describing the more recent *modus operandi* followed by the Central Bank of Brazil concerning reserve requirements.

that, to a certain extent, market participants have been able to anticipate some policy actions taken by the COPOM.

The VAR literature using Brazilian monetary data is not very vast. Pastore (1995, 1997) investigated inflation persistence and the passiveness of money supply to the inflation rate. Fiorenco and Moreira (1999) used a variable-coefficient VAR to assess the effectiveness of monetary policy in different periods. Rabanal and Schwartz (2001) used 1995-2000 data to investigate output and money response to interest-rate shocks. Minella (2001, 2003) used monthly data from 1975 to 2000 to investigate the link between interest rates, money and output and to compare three distinct periods of the Brazilian economy.

This work intends to add to the Brazilian monetary literature in two respects. First, a solution to Taylor's model is presented as a tool in the understanding of the link between the target interest rate and the overnight interest rate. The main conclusion of this analysis, and the result that links it to the Vector-Auto-Regression (VAR) analysis carried out in the second part of this work is that, for reasonable values of the underlying parameters, the convergence of interest rates to the target interest rate (which takes some days) can be assumed to be practically negligible when compared to a time interval of one quarter. By defining the time of the shock as that in which the news are released, this allows for an interpretation of changes in the target interest rate as shocks to interest rates.

The second part of the work carries out a VAR analysis with the purpose of investigating how the dynamics of certain key macroeconomic variables changes as a function of shocks to interest rates. More particularly, I will be interested in the quantitative effects of a 1% unexpected increase of the target interest rate on prices, output and reserves. The estimation of the four-year accumulated output response will receive particular attention.

As it is always the case in such analyses, all results are contingent on the particular Cholesky decomposition chosen for the impulse-response estimation and on the assumption that the relevant sigma algebra on which economic agents base their expectations is the one generated solely by the series and lags used in the econometric estimations.

2 Taylor's Model

Taylor (2001) offers an easily readable model in which supply and demand for bank reserves are written, respectively, as³:

$$b_t = b_{t-1} + \beta(r_{t-1} - \rho_{t-1}), \quad \beta > 0 \quad (1)$$

and

$$b_t = -\alpha(r_t - \gamma E_t r_{t+1}) + \varepsilon_t, \quad \alpha > 0, \quad 0 < \gamma < 1 \quad (2)$$

The first equation says that the supply of bank reserves (b) is increased, at time (day) t , by (indirect) actions of the Desk, when the interest rate in period $t - 1$ is higher than the targeted interest rate (ρ) at period $t - 1$. The second equation translates the demand of reserves by the banks. This demand is positive when banks expect, conditionally on the information set available at date t , that interest rates, corrected for the parameter γ , will increase from one day to another.

An important point in the understanding of Taylor's model is that the time period in which the variables in the model are accounted for (here, one day) is much smaller than the time period in which banks must average their reserves in order to comply with the reserve requirements set by the Central Bank (usually, in Brazil, a period of ten business days). This implies that, even with a partially lagged calculation of reserve requirements⁴, banks still have freedom enough to make (daily) adjustments of their reserve balances.

In terms of the classification presented in Simonsen and Cysne (1995, p. 656), this is a mixed system of stochastic difference equations, since there are autoregressive and forward looking components. By assuming that information is not lost over time, (2) and the law of iterated expectations lead to:

$$E_{t-1}r_t = -\frac{1}{\alpha} \sum_{j=0}^{\infty} \gamma^j E_{t-1}b_{t+j} + \lim_{n \rightarrow \infty} \gamma^n E_{t-1}r_{t+n}$$

which shows how the value interest rates expected to prevail in the future affect the present interest rate.

Taylor (2001) does not explicitly solve the system of equations given by (1) and (2).

³I am using the term "bank reserves" as a shortening to "bank reserves held as deposits in the Central Bank". This corresponds to what Taylor (2001) calls "fed balances".

⁴Currently, in Brazil, as established by the Circular 2986, of June 23, 2000, reserve requirements for each of two groups of banks are calculated taking into consideration balances measured from business day 1 to business day 10, whereas maintained reserves are averaged between business day 8 and business day 17. The system, therefore, cannot be classified as a lagged one, since there is an intersection of 3 business days (8, 9 and 10), out of 10, between measurements and compliance. But it is close to that.

This can be easily done, under perfect foresight, in the case of an autonomous system ($\rho_t = \rho$ for all t). By writing:

$$z_t = \begin{bmatrix} b_t \\ r_t \end{bmatrix}, \quad A = \begin{bmatrix} 1 & \beta \\ \frac{1}{\alpha\gamma} & \frac{1}{\gamma} \end{bmatrix}, \quad C = \begin{bmatrix} -\beta \\ 0 \end{bmatrix}$$

(1) and (2) read:

$$z_{t+1} = Az_t + C\rho \quad (3)$$

The fixed point and the characteristic equation of (3) are, respectively,

$$\bar{z} = (I - A)^{-1}C\rho = \begin{bmatrix} -\alpha(1 - \gamma)\rho \\ \rho \end{bmatrix} \quad (4)$$

and

$$f(\lambda) = \lambda^2 - \frac{1 + \gamma}{\gamma}\lambda + \frac{\alpha - \beta}{\alpha\gamma}$$

I will concentrate here only in the generic case in which the eigenvalues are real and distinct. In this case the eigenvectors generate \mathbb{R}^2 and we can consider the inverse of the matrix formed by the eigenvectors of A . The eigenvectors $e_1 = (e_{11}, e_{12})$, $e_2 = (e_{21}, e_{22})$ can be taken to be $e_1 = (1, \frac{-1}{\alpha(1-\gamma\lambda_1)})$ and $e_2 = (1, \frac{-1}{\alpha(1-\gamma\lambda_2)})$, where λ_1 and λ_2 are the respective eigenvalues. By making $P = (e_1, e_2)$ and defining $\hat{z} = P^{-1}z$, we have the system in diagonalized form:

$$\hat{z}_{t+1} = D\hat{z}_t + P^{-1}C\rho$$

where D is a diagonal matrix having in the diagonal the eigenvalues λ_1 and λ_2 . The general solution reads $\hat{b}_t = c_1\lambda_1^t$ and $\hat{r}_t = c_2\lambda_2^t$, the hats over the variables having the obvious meaning.

Assuming that the parameters of the model generate $|\lambda_1| < 1$ and $|\lambda_2| > 1$, the transversality condition (saddle-path solution) implies $c_2 = 0$. Using (4) we have, in terms of the original variables of the system (since $z = P\hat{z}$):

$$\begin{bmatrix} b_0 \\ r_0 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ \frac{-1}{\alpha(1-\gamma\lambda_1)} & \frac{-1}{\alpha(1-\gamma\lambda_2)} \end{bmatrix} \begin{bmatrix} c_1 \\ 0 \end{bmatrix} + \begin{bmatrix} -\alpha(1-\gamma)\rho \\ \rho \end{bmatrix}$$

which determines c_1 as a function of b_0 . The general solution then reads:

$$b_t = (b_0 - \alpha(\gamma - 1)\rho)\lambda_1^t + \alpha(\gamma - 1)\rho, \quad t \geq 0 \quad (5)$$

$$r_t = \frac{-(b_0 - \alpha(\gamma - 1)\rho)\lambda_1^t}{\alpha(1 - \gamma\lambda_1)} + \rho, \quad t \geq 1 \quad (6)$$

Equations (5) and (6) determine the evolution of the endogenous variables b and r , under different values of the parameters α , β and γ , when there are changes of the target interest rate ρ .

Taylor uses the parameter values $\gamma = 0.9$, $\alpha = 0.3$ and $\beta = 0.1$ to draw Figure 5 in his work. Figure 5 shows the evolution of interest rates when the target interest rate changes from 0 to 0.5. The economy is supposed, previously to period zero, and including period zero, to be in a steady state with $\rho = r = 0$ and $b = b_0 = 0$ (the fact that $b_0 = 0$ follows from equation (2), since in the steady state $r_t = E_t r_{t+1}$).

Note from (5) and (6) that when $\gamma = 1$, $b_t = b_0 = 0$ for all t , even though the interest rate immediately adjusts to its new level. In other words, there is no need of open market operations to change interest rates. This is what Thornton (1999) and Guthrie and Wright (2000) referred to as "Open Mouth Operations"⁵.

Below I present some additional simulations of the solutions to (1) and (2) using parameter values other than those used by Taylor:

Insert Figure 1 Here

Note that the higher the value of gamma (see Furfine (2000) for empirical considerations regarding this parameter), the less time it takes for interest rates and reserves to converge to the new steady states. Seeing the figures in Figure 1 as disposed like a 2x3 matrix, Figures 1x3 and 2x3 show the instantaneous adjustment of interest rates and the invariance of the total level of reserves when $\gamma = 1$, the case described above as the "open mouth" case. Figure 2x2 corresponds exactly to Figure 5 in Taylor (2001).

Figure 2 below shows the evolution of the interbank rate (SELIC - Sistema Especial de Liquidação e Custódia) and the target rate between 07/1999 and 01/2003:

Insert Figure 2 Here

Except for June/02, one can see in Figure 2 that the discrepancy between the rates are usually very small.

3 Innovation Accounting

The previous section shows that, under reasonable assumptions regarding the parameters of Taylor's model, one can expect the overnight interest rate

⁵See Martins (2003) for an analysis of the possibility of "open mouth" operations in Brazil (this author calls it "efeito anúncio" (ad. effect)).

to converge to the new target announced by the monetary authorities in a period ranging from one to ten days.

From this section onwards, our time period will be of one quarter and our horizon of analysis will take a total of four years. Since a ten-days period under this horizon is practically negligible, one can associate news of changes in the target rate with immediate shocks to interest rates. Besides being supported by the logic behind Taylor's model, this procedure can be justified by the data displayed in Figure 2.

With this in mind, from now on my purpose will be using impulse-response and variance-decomposition analyses to study what happens to output, price level, and bank reserves, once interest rates are increased by one percentile point (a hundred basis points)⁶.

Initially, I derive qualitative considerations working with the whole sample period in which the macroeconomic variables under consideration are available on a quarterly basis: 1980 : 1 – 2004 : 2. Later on in this section I will use a subsample with data collected after the Real Plan (1994 : 2 – 2004 : 2).

3.1 Confidence Bands: Bias-corrected Bootstrap

As in Cysne (2004), here I use the confidence bands for the impulse-response functions based on Kilian's (1998) bias-corrected bootstrap method.

The application of the standard bootstrap procedures to auto-regressive models generates replicates which are necessarily biased, on account of the small-sample bias of the estimators of the parameters. In order to deal with this problem, specifically regarding the confidence intervals for impulse-response functions constructed from VAR estimates, Kilian (1998) proposed correcting the bias prior to bootstrapping the estimate.

Monte Carlo studies carried out by this author (see p.222 in Kilian (1998)) show that the relative frequency at which the 95% confidence interval covers the true impulse response (in a model like the one used here) can be as low as 50% when standard bootstrap methods are employed. The bias-corrected bootstrap, on the other hand, presents a frequency around 90-95%⁷.

In the estimations in levels and without trends, I employ Pope's (1990) closed-form solution to the bias of the estimators of the VAR. The theorem reads:

⁶For the effect of changes in the target rate on the term structure of interest rates, in the Brazilian case, see Tabak (2003).

⁷The bias-corrected bootstrap detailed here has been primarily designed for stationary VARs. However, Kilian (1998, section VI) demonstrates that this technique may still be satisfactory, in practice, for nonstationary processes estimated in levels.

Theorem 1 (Pope (1990)): Let \hat{A}_n be the least-squares estimator of A in the m -dimensional $AR(1)$: $X_t = AX_{t-1} + Z_t$, in which X_t and Z_t are $m \times 1$ and A is $m \times m$, based on a sample of size n . Make:

$$C_n(s) = \frac{1}{n-1} \sum_{i=1}^{n-1} U_{i-s} U_i^T$$

where $U_t = X_t - \bar{X}_n$, \bar{X}_n the sample mean. Suppose that, for some $\varepsilon > 0$, $E \| C_n(0)^{-1} \|^{1+\varepsilon}$ ($\| \cdot \|$ states for the operator norm) is bounded as $n \rightarrow \infty$ and that the innovations Z_t are a martingale difference sequence such that all moments of Z_t up to and including the sixth, conditional on the past, are finite and have values independent of t . Let G denote the conditional covariance of Z_t , and suppose that $\| A \| < 1$. Then, as $n \rightarrow \infty$, the bias $B_n = E\hat{A}_n - A$ is of the form:

$$B_n = -\frac{b}{n} + O(n^{-3/2}) \quad (7)$$

where b is given by:

$$b = G \left[(I - A^T)^{-1} + A^T (I - (A^T)^2)^{-1} + \sum \lambda (I - \lambda A^T)^{-1} \right] \Gamma(0)^{-1} \quad (8)$$

The sum is over eigenvalues of A , weighted by their multiplicities, and $\Gamma(j) = EX_t X_{t+j}^T$.

Proof. See Pope (1990). ■

The key point to note is that the bias for the bootstrap is re-estimated, and new coefficients are generated, in each resampling of the bootstrap.

3.2 Impulse-Response Functions

Let y , p , r , res and m denote, respectively, the logarithm of real GDP , the logarithm of the price index, the short term (SELIC) interest rate, the logarithm of total (bank) reserves and the logarithm of M_1 (means of payment). The primitive data on p , m and r used here are from IBRE-FGV's (Instituto Brasileiro de Economia da Fundação Getulio Vargas) data bank. The quarterly GDP index and bank reserves are from IPEA (Instituto de Pesquisa Econômica Aplicada.).

In all estimations in this work, the benchmark specification used, regarding the ordering of the variables in the VAR, is the same as in Christiano et al. (2000). Under this ordering, the information set assumed to be available

to the government at time t , when choosing the interest rate to target, includes the current and lagged values of y and p , as well as lagged values of r , res and m . As a consequence of the ordering of the variables in the VAR and of the Cholesky-orthogonalization assumption, neither the price level at time t nor the GDP at time t are supposed to change as a consequence of a contemporaneous interest-rate shock⁸.

- Results For The Model in Log Levels

Since the main goal here is to determine the interrelationships among the variables, not the parameter estimates, in this subsection I follow Sims's (1980) and Doan's (1992) suggestions⁹ and estimate the VAR in log levels .

A preliminary analysis of this data set has been carried out by Cysne (2004). Using the Akaike and the Schwarz criteria¹⁰, the model with 12 lags outperformed the models with 4 and 8 lags.

For these reasons, regarding the estimation in levels and with the whole data sample, I shall work here only with 12 lags. Figure 3 shows the response of output and prices to an increase of one-percent deviation in interest rates, using a VAR in log levels with a nonzero intercept and 12 lags:

Insert Figure 3 Here

The four sub-figures in Figure 3 display the response of y , p , r and res to a one percent increase in interest rates. All variables are in percentage terms.

⁸The fact that interest rates do not affect output contemporaneously can be justified by previous work of Bogdanski et al (2000), who found, using structural models, that interest rate changes affect aggregate demand only after a period of 3 to 6 months.

⁹See also Enders (1995, p. 301).

¹⁰The maximum estimated absolute value of the eigenvalues of the A.R. matrix for 4, 8 and 12 lags are, respectively, 0.9815, 0.9829 and 0.9930. Reestimations of the VAR over the same sample period lead to values of the Akaike Information Criterion, respectively, for the model with 4, 8 and 12 lags, of 1.0969 1.1392 and -0.7527. This suggests the use of the model with 12 lags. Even though we are dealing with a small sample, I also performed a log-likelihood test under a null of 12 lags and an alternative of 8 lags. Asymptotically, $c = 2 * (L12 - L8)$ has a chi-square distribution with 100 ($5^2.4$) degrees of freedom. The value found was 367.2, confirming the Akaike-Criterion option for 12 lags. Sims' (1980) bias-corrected version of this test calls for multiplying this statistics by $(n_1 - n_2)/n_1$, where n_1 is the number of periods effectively used in the regressions and n_2 is the number of parameters estimated in the equation with the highest number of parameters. This leads to a new statistics $s = 367.2 * (86 - 61)/86 = 106.74$. The new p-value of 0.3049 does not point out so definitely in favor of 12 lags.

As one can observe from the " $r \rightarrow y$ " figure, the product declines in the first quarter to a maximum around 0.04% but recovers before the end of the year¹¹. There is a rebound after the end of the first year and a subsequent decline one quarter afterwards, which lasts for two years. A new rebound after the third year, around 0.03%, is then followed by a further decline. Note that the 95% confidence bands include zero as a valid response throughout the whole four-year period after the shock.

By aggregating the effects over the GDP over a four-year horizon one finds an accumulated product decline around 0.07%, with lower and upper bounds of -0.22% (GDP loss) and 0.20% (GDP gain).

Regarding the effect on prices, as shown by Cysne (2004), there is a subtle price puzzle in the first quarter after interest rates are increased. As of this date, though, the effect of interests on prices is of a four-year persistent decline. In this case, a null response can be statistically rejected the first year after the shock onwards.

Note that both output and prices are not contemporaneously affected by the shock in interest rates, a consequence of the economic assumptions leading to the particular Cholesky decomposition used in the simulations.

Regarding the interest rate itself, the shock starts at the level of 1%, and lasts around one quarter.

Finally, with respect to bank reserves, the contemporaneous effect is negative, showing a decline around 0.4%. A rebound at the end of the first quarter lasts for three quarters. After the end of the first year, the negative effect of interest rates on reserves lasts for the next three years, reaching a maximum response of a decline around 3% at the fourteenth quarter after the shock.

- Trends and Unit Roots

It is a valid exercise checking how the results obtained by running the VAR in log levels, without a trend, could change by using first differences of the nonstationary variables, or by the introduction of a time trend for the regressions run in log levels. The respective impulse-response functions are shown in Figures 4 and 5.

The results in differences were obtained with four lags. To avoid clustering the analysis, and since the objective of this section is primarily a comparison with the estimation in log levels, I do not include confidence bands.

¹¹Considering only the initial cycle shown by GDP, this is in agreement with Lisboa (2004), who has argued that the short-run effect, on output and employment, of an increase of the target interest rate by the COPOM is temporary and lasts less than a year.

Insert Figure 4 and 5 Here

Regarding the estimation in log levels with a trend (the nonzero intercept is assumed in all cases), the overall shape of the responses of all variables is practically the same as in the case without trend. This could be expected, given the large number of regressors in each equation. A quantitative difference is that now the overall decline of product along the four years is found to be 0.04%, a bit lower than the previous 0.07%.

Qualitatively, imposing unit root to the nonstationary variables leads to some changes in the shape of the responses, but not significant ones (Figure 5). The response of GDP is practically the same till the end of the first year. There is initially a decline around 0.04%, followed by a recovery that lasts till the end of the first year. In contrast to the estimation in levels, though, the oscillations of output are now less subtle, remarkably between the first and the fourth year. In both estimations output is back to its initial level forty eight months after the initial shock.

The value of the accumulated decline in *GDP* over the four years now amounts to 0.08%, a bit higher than the previous 0.07% regarding the estimation in levels without trend.

The price puzzle is a bit longer when the estimation is done with first differences, lasting between six to nine months, but always less than 0.2%. The response of prices is steadily negative after the first year, repeating the previous result.

Regarding interest rates, the shock initial 1% shock lasts for around six months, as opposed to the previous three months of the estimation in levels without trend. The final effect at the end of the fourth year is a decline of interest rates, repeating the estimation in levels.

The contemporaneous effect on bank reserves is now positive (around 0.2%), in a subtle contrast with the estimation in levels. But after the end of the first year, both estimations show a steady decline, which reaches a value between 2% and 3% at the end of the fourth year.

3.3 Variance Decomposition

The purpose of this subsection is to measure the proportion of movements in each of the sequences considered that can be attributed to its own shocks, or to shocks to other variables. The same assumptions regarding the ordering of the variables in the VAR used to obtain the impulse-response functions apply here. The horizon considered is of four years. I provide variance decomposition for the model in log levels only.

Insert Figure 6 Here

The results displayed in Figure 6 show that interest rates explain a relatively small share of the conditional variance of GDP (4.9%). Regarding prices, interest rates, bank reserves and money, though, the effect of shocks to interest rates in explaining forecast errors is usually very relevant. Unexpected movements in interest rates account for around 39% of the variance of prices, 35% of the variance of bank reserves and 36% of the variance of M_1 . Except for the effect on GDP, shocks to interest rates play a more important role in explaining forecast errors than shocks to money. Price and interest-rate shocks, alone, explain around 80% of the forecast errors in reserves and money.

4 Subsampling: Results For The Post-Real Economy

The results obtained so far are satisfactory from a qualitative perspective but may not be ideal for a description of the economy after the Real Plan. The main reason is that as of 1994 : 2, macroeconomic variables evolved under a very different pattern.

For instance, the standard deviations of the residuals in the estimation of y , p , r , res and m are much higher when one considers the whole sample than when one only includes Post-Real data. Following a signal-extraction reasoning, the effect on GDP of a 1% shock to interest rates after the Real Plan should be higher than the one measured in a sample including data both before and after the Plan. On the other hand, subsequent variations of the interest rate should show an opposite pattern.

In this section I resample the data to include only the 1994:2 - 2004:2 (after Real) period and show that both of these facts indeed occur.

Since I am using quarterly data (there are no monthly estimates of GDP in Brazil), this procedure leaves too little degrees of freedom to consider more than four lags.

The product and interest-rate response are shown in Figure 7:

Insert Figure 7 Here

Note that, consistently with the fact that a one percent shock to interest rate before the Real Plan should lead to a smaller response from the economy than after the Real Plan, the new estimations show a much higher initial

decline of output (1%, as compared to 0.04% when the whole sample is used). Although one must take into consideration that now we are using only 4 lags, instead of 12, the initial decline of GDP is now much more resilient than in the case of the full sample, lasting $1\frac{1}{2}$ years, instead of the initial 11 months.

In contrast to the estimations when the whole sample is used (see Figure 2), the 95% confidence bands here do not include zero as a statistically valid output response in the first six months after the shock.

The new accumulated output loss is 0.25%. Using the lower and upper bands lead to a GDP variation of -3.54% and 3.48% .

Also as expected, interest rates now reach a lower bound around -0.4% , much lower (in absolute value) than the -1.4% obtained when the pre-Real data was included.

The new variance decomposition for the subsample 1994:2-2004:2 is presented in Figure 8.

Insert Figure 8 Here

The results displayed in Figure 8 show that interest rates in the more recent period explain a larger share of the conditional variance of GDP (9.2%, as opposed to the previous 4.9%). Unexpected movements in interest rates now account for 2.14% of the variance of prices, 20% of the variance of bank reserves and 6% of the variance of M_1 . Shocks to money are now more important than shocks to interest rates in explaining errors in the forecast of all variables, except interest rates themselves.

5 Conclusions

This work has started with a short description of the two-target mechanism that characterizes the state of monetary policy in Brazil after 1999. Next, Taylor's model for the determination of bank reserves and interest rates was revised and simulated for different parameter values. A particular configuration of the parameters has been noticed to lead to what is generally called "open-mouth" operations, as opposed to "open-market" operations.

The second part of the paper provides a VAR analysis of the effects over output, interest rates, prices and bank reserves, of a 1% shock to the interest rate caused by an unexpected increase of the target interest rate in the same amount.

Point estimates show a four-year accumulated output loss ranging from 0.04% (estimation in log levels with a constant, using 1980 : 1-2004 : 2, quarterly data) to 0.25% (estimation in log levels, without a constant, using

only Post-Real data) with first-year peak output response between -0.03% and -1.0% , respectively. Prices always fall between 2% and 4% along the 4-year horizon. The accumulated output response is found to be between 3.5 and 6 times higher after the Real Plan than when the whole sample is considered. In all estimations including the whole sample, the 95% confidence bands obtained using bias-corrected bootstrap include the null output response. The same, though, does not happen when one uses only Post-Real data. Innovations to interest rates explain between 4.9% (whole sample) and 9.2% (post-Real sample) of the forecast error of GDP.

Qualitatively, a negative correlation between the target rate and prices, as well as between the target rate and output (or bank reserves) is robust to the method of estimation (if with or without a constant and if in levels or in first differences) and to a subsampling that includes only the data after the Real Plan.

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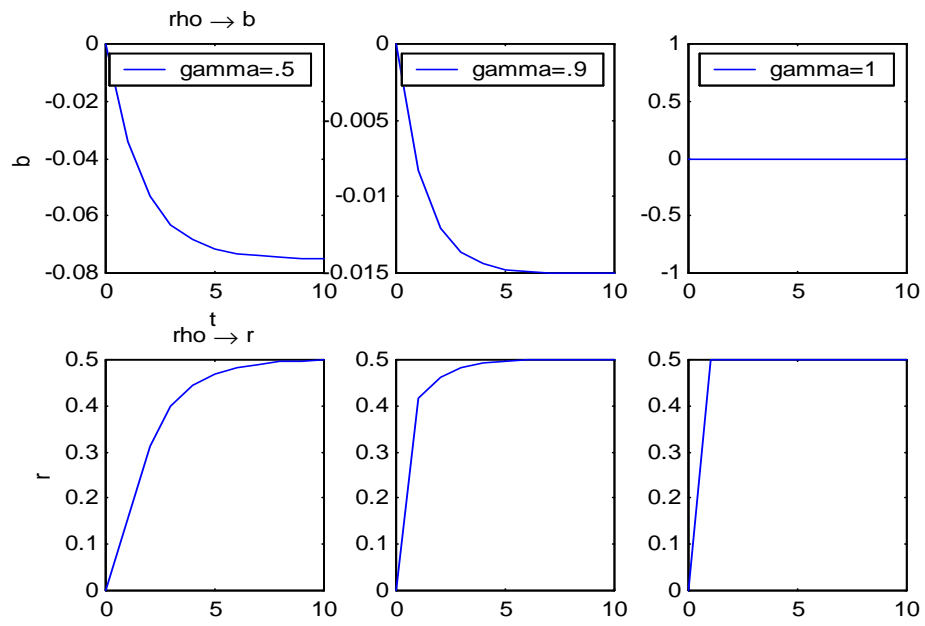


Figure 1: Response of Reserves and Interest Rates to a Unanticipated 0.5% Increase in the Target Rate

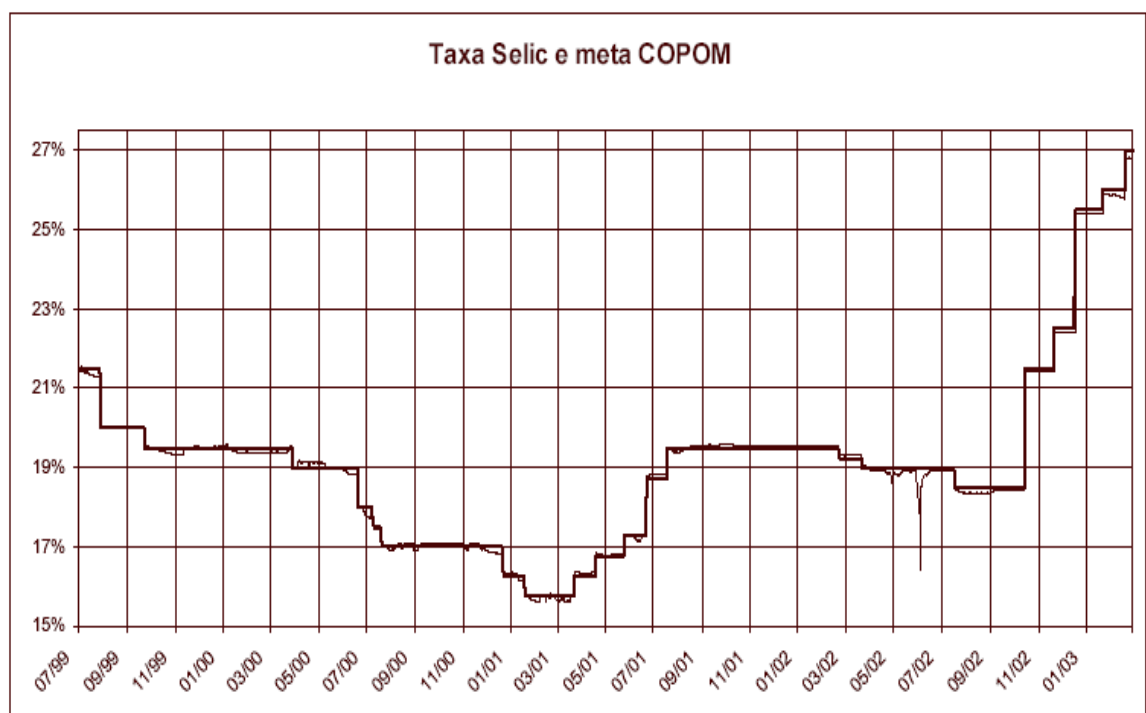


Figure 2: Interbank Rate and Targe Rate (Flat) Source: Martins (2003)

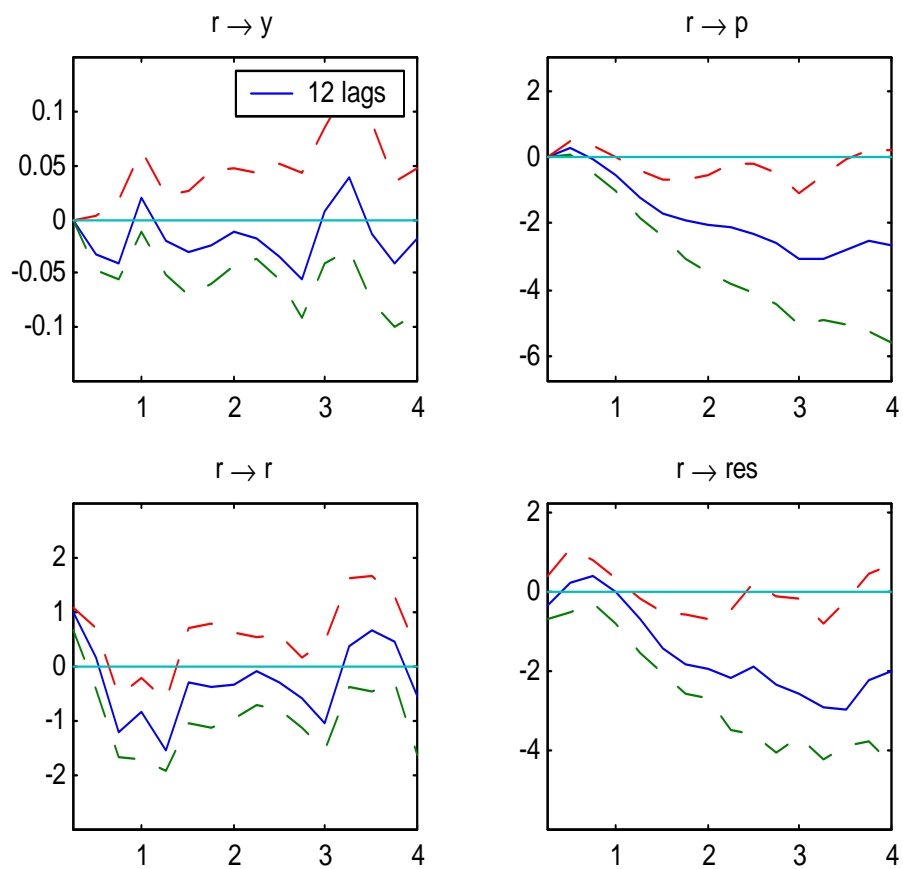


Figure 3: Impulse-Response Functions, VAR in Levels Without Trend. Sample: 1980:1-2004:2

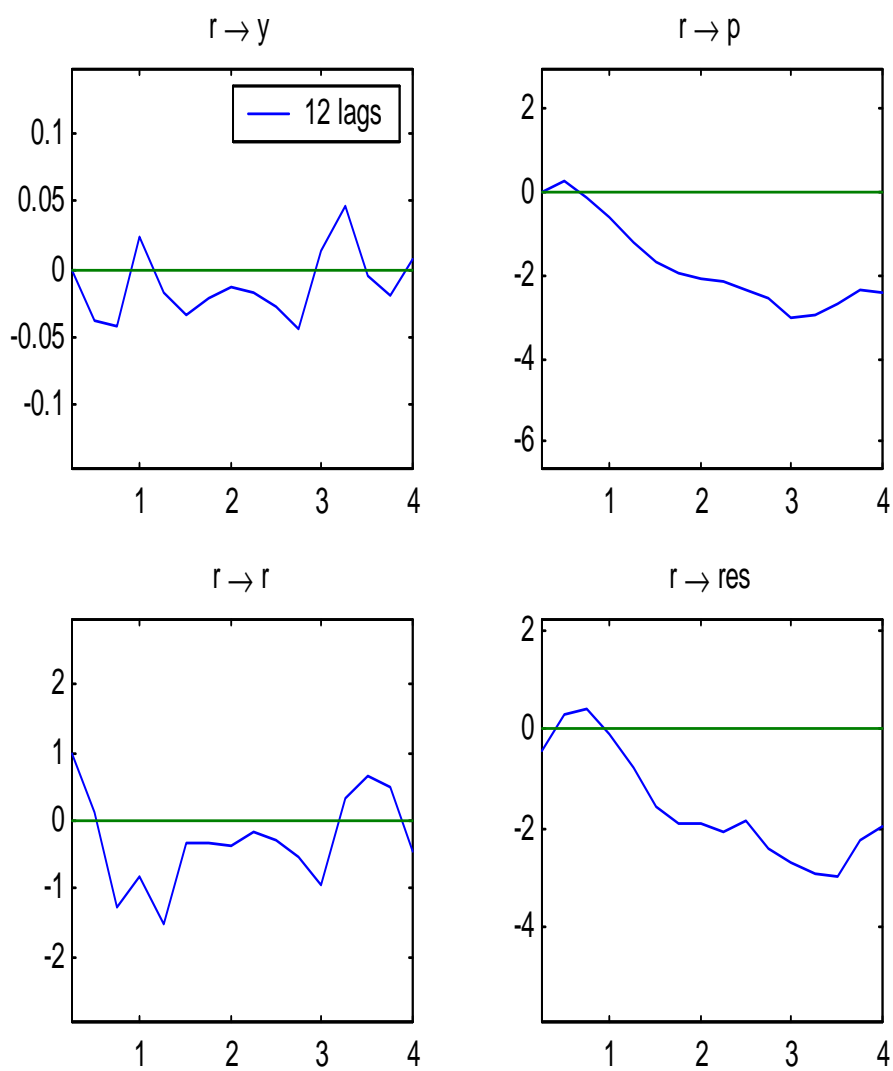


Figure 4: Impulse-Response Functions, VAR in Levels With a Trend. Sample: 1980:1-2004:2

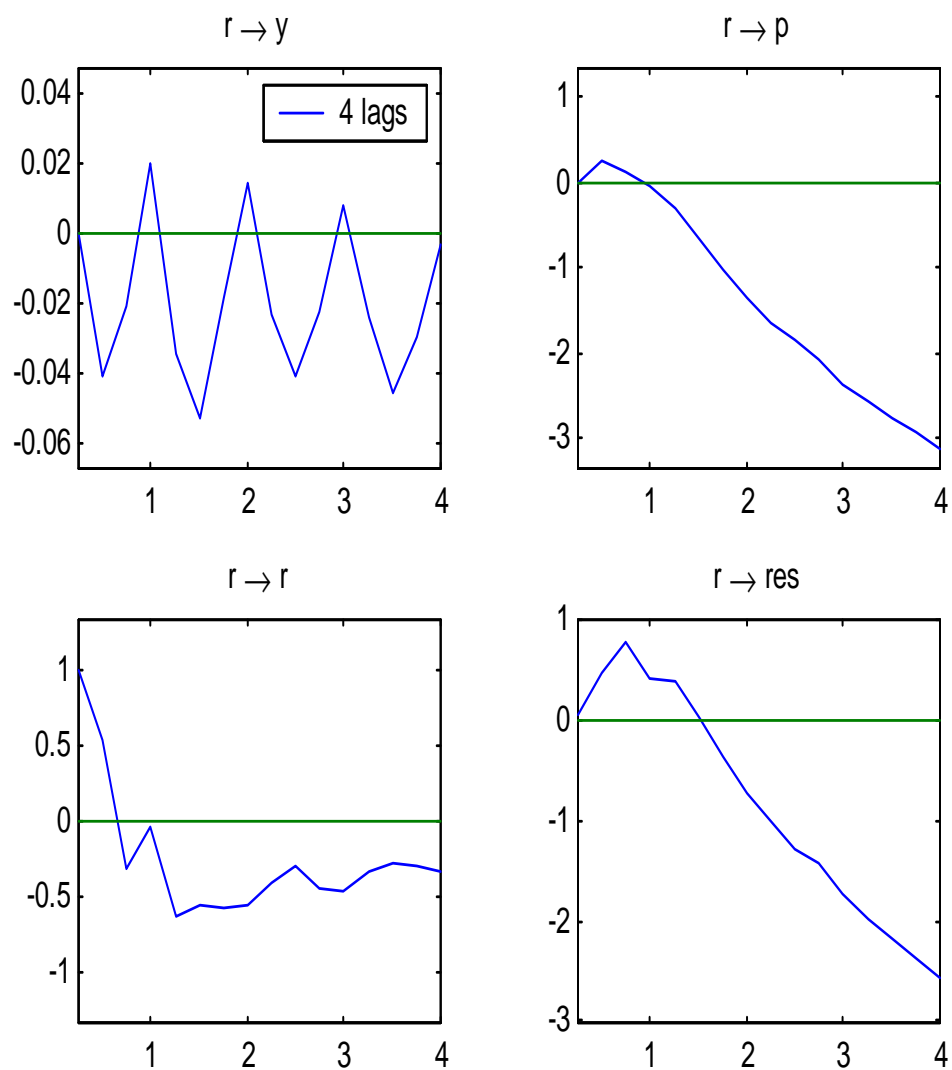


Figure 5: Impulse-Response Functions, VAR in First Differences. Sample: 1980:1-2004:2

Percentages of Forecast Error Variances in Rows Explained by Columns =

	y	p	r	res	m
y	54.08730	11.70066	4.90401	14.50732	14.80071
p	2.43134	42.82727	38.62835	1.64687	14.46617
r	7.30486	25.89850	29.27254	9.77499	27.74911
res	5.56446	42.34591	35.69846	4.44005	11.95111
m	4.40031	45.37274	36.28659	1.10138	12.83899

Figure 6: Variance Decomposition, Model in Log Levels

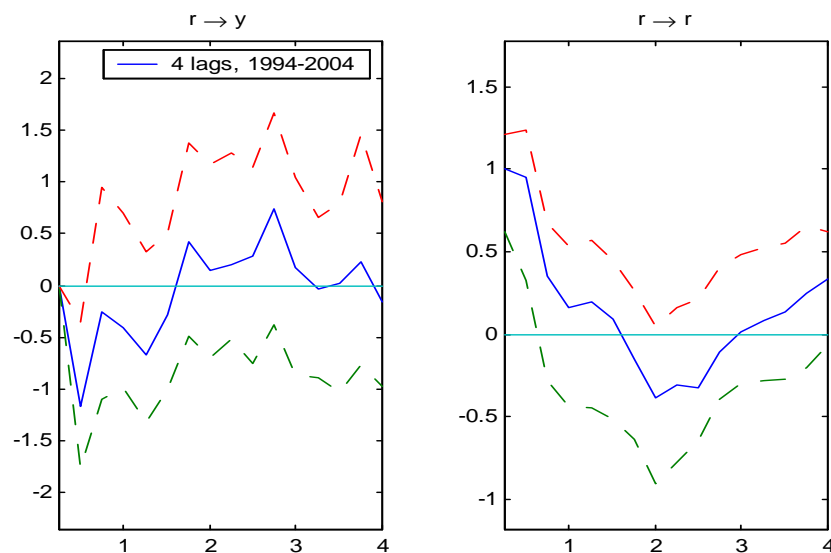


Figure 7: Response GDP and Interest-Rate Response to a 1% Increase of the Target Interest Rate, Subsample 1994:2-2004:2. Estimation in Levels.

	y	p	r	res	m
y	46.13374	10.91058	9.16962	17.78556	16.00050
p	12.68885	41.16261	2.14983	14.14951	29.84920
r	6.72749	8.14970	46.39913	23.07689	15.64679
res	8.23052	11.24385	19.88458	34.12436	26.51669
m	18.65238	22.99661	6.22818	16.92237	35.20046

Figure 8: Variance Decoposition, Model in Log Levels, Subsample 1994:2-2004:2

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